Developed by Monarch Joint Venture's Data & Information Working Group, this Monarch Research Priorities document was designed to inspire collaborative and meaningful research that addresses key data gaps in monarch conservation. The document contains a synthesis of monarch research priorities (Section A), data sources that could be leveraged to advance specific research priorities (footnotes and Section B), potential relevant funding sources (Section C), and the conservation plans and experts consulted to generate the list of research priorities.

A. Monarch Research Priorities

Conservation Effectiveness and Opportunity

1. Evaluate effectiveness of conservation actions and communication strategies, and generate or modify best management practices accordingly.[B]
2. Identify and evaluate factors that influence adoption of monarch conservation actions (e.g., costs, benefits, barriers, sociological considerations, public awareness, impacts on other species).
3. Develop regional guidance and standards for selecting and growing milkweed and nectar plants for habitat restoration and enhancement activities throughout the US.
4. With landscape connectivity in mind, identify high priority migratory pathways, clustering locations, and breeding areas throughout the monarch's range.[B]
5. Identify land that is available for monarch conservation actions, especially that which is underutilized.
6. Develop standard indicators to evaluate the effectiveness of economic incentives to conserve monarch habitats.

Data Efficacy

1. Coordinate monitoring efforts via development and distribution of monitoring protocols, with an emphasis on existing protocols and data standardization and sharing.
2. Identify gaps in existing datasets to inform future habitat conservation research.
3. Maintain trinational research collaboration and develop ways to improve trinational data compatibility (e.g., seamless land use maps, pesticide use maps).

Breeding Habitat Use and Distribution

1. Study the species-specific relationships of monarchs and their host plants, nectar plants and staging/roosting sites, and determine what characteristics impact these relationships at various scales, geographies, and seasons.[A]
2. Quantify habitat gains and losses by state, sector, and land-use type.
3. Evaluate habitat quality (e.g., milkweed density, floral resource availability) by state, sector, and land-use type.
4. Determine how spatial distribution of milkweed at local and landscape scales affects survival and movement.[B, C, K, N]

5. Evaluate costs for effective establishment, maintenance, and monitoring of habitat.
6. Understand movement and spatiotemporal use of habitat along migratory routes and throughout the breeding season.[B, C, D, H]

Overwintering

1. Monitor and quantify annual gain, loss, or degradation of monarch overwintering habitats in Mexico and the western US and identify the factors attributable to such change (e.g., logging, land use change, weather/climate change, tourism, management).[F]
2. Assess monarch's use of overwintering habitat at multiple scales (e.g., microhabitat, landscape-scale, core area, buffer area).[D,E,F]
3. Evaluate how a changing climate and changes in water availability will impact overwintering sites in the future.[A]
4. Investigate the causes and normal rates of overwintering mortality, and movement among colonies, to better understand and mitigate risks.[D,E,F]
5. Identify nectar sources important for monarchs overwintering in western North America.[B,G,H]
6. Study the impacts of disease, pests, or noxious species, such as dwarf mistletoe, on *Abies religiosa*.
7. Develop methods to increase the accuracy of mapping and quantifying overwintering colonies (e.g., drones, improved monarch density estimates).

Population Dynamics

1. Develop assays to assess physiological performance of monarchs.
2. Gain a comprehensive understanding of each state/province's role in supporting the overall monarch population.[I]
3. Obtain a better understanding of monarch distribution by state.[B,H,J,K]
4. Identify and document monarch migration roost/staging areas and how these areas may shift due to weather, climate change, or other factors.[M]
5. Identify and understand the limiting factors surrounding a successful migration (e.g., topography, natural disasters, habitat loss, artificial overwintering habitat, fire ants, climate change).[D,J]
6. Evaluate survival by life stage (including migration) and reproductive success by generation (including winter breeding) to determine which stages may have the greatest impact on population growth.[B,C]
7. Model connectivity and conservation along the migratory route, including consideration of different levels of adoption of conservation actions by land use type.
8. Generate updated population models that incorporate the most current monitoring data.
9. Improve understanding of population structure through novel techniques (e.g., genetic diversity indicators).
10. Understand the interactions between overwintering migratory monarchs and resident monarchs in the western US (e.g., effects on OE spread, diapause, and mating).[B, C, D, N]

Threats

1. Determine the direct impact of pesticides on all monarch life stages.[B, C]
2. Evaluate pesticide applications and off-target contamination (e.g., drift) to minimize and mitigate risks.
3. Quantify variation in *Ophryocystis elektroscirrha* (OE) virulence across the monarch range and research the selective pressures on OE.[N]
4. Investigate the transmission of OE between migratory and resident monarch populations.[N]
5. Study effects of climate change (including severe weather events, pollution, increased UV exposure, increased CO_2, and invasive species) on monarch habitat and monarch population viability.[A]
6. Develop habitat management procedures to address the potential impacts of climate change on nectar plant diversity and monarch migration.
7. Predict potential changes in milkweed and nectar plant ranges and physiology across the breeding range under different climate scenarios.[A]
8. Understand impacts of wildfire on monarchs.
9. Assess potential impacts of human-made structures on monarch habitat, migration, and survivorship (e.g., roads, wind turbines, solar fields).[B]
10. Assess effects of land use changes on monarchs and milkweed.[B]
11. Assess impacts of captive rearing and release on monarch populations.
12. Assess impacts of non-native milkweed species on monarch health, behavior, and reproduction.[B, C, N]

B. Potential Monarch & Milkweed Data Sources

A. USA National Phenology Network
B. Integrated Monarch Monitoring Program (IMMP)
C. Monarch Larva Monitoring Project (MLMP)
D. Monarch Watch
E. Southwest Monarch Study
F. Western Monarch Count
G. Monarch Nectar Plant Database
H. North American Butterfly Association (NABA)
I. State-based natural heritage programs
J. Journey North
K. Western Monarch Milkweed Mapper
L. Nature Serve
M. State & national land trust botanical surveys on private lands
N. Project Monarch Health
O. iNaturalist
P. Nature Counts Trinational Monarch Knowledge Network
Q. Budburst

C. Potential Funding Sources

1. Xerces Society Joan Mosenthal DeWind Award (students only)
2. Monarch Butterfly Fund's Lincoln P. Brower award (students only)
3. USGS research grants (see grants.gov)
4. USFWS research grants (see grants.gov)
5. NRCS Conservation Innovation Grants
6. USDA Monitoring Assessment & Evaluation grants
7. National Cooperative Highway Research Program
8. State Departments of Transportation
9. BLM's Plant Conservation & Restoration Program
10. *Consider embedding research objectives within monitoring related to habitat enhancement projects or collecting monitoring data in a way that contributes to these research objectives.*
11. Xerces' Society Deborah BanDrosky Award
12. Idaho Native Plant Society Education Research Inventory Grant
13. Illinois Native Plant Society grants

D. Conservation plans and input reviewed for this synthesis

- North American Monarch Conservation Plan (2008)
- Monarch Butterfly Conservation Strategy for the Eastern Region of the USDA Forest Service (2017)
- Nebraska Conservation Strategy for Monarchs and Pollinators (2017)
- South Dakota Monarch Conservation and Management Strategy (2018)
- Iowa Monarch Conservation Strategy (2018)
- Wisconsin Monarch Strategy (2018)
- Missouri Monarch and Pollinator Plan (2021)
- Kansas Monarch Conservation Plan (2019)
- Illinois Monarch Action Plan (2020)
- New Jersey Monarch Butterfly Conservation Guide (2017)
- Management Plan for the Monarch in Canada (2016)
- Texas Monarch and Native Pollinator Conservation Plan (2016)
- North Dakota Monarch Butterfly and Native Pollinator Strategy (2018)
- Kentucky Monarch Conservation Plan (2018)
- Oklahoma Monarch and Pollinator Collaborative Statewide Monarch Conservation Plan (date unknown)
- Indiana Monarch Conservation Plan (2018)
- WAFWA Western Monarch Conservation Plan (2018)
- MAFWA Mid-America Monarch Conservation Strategy (2018)
- Trinational Monarch Conservation Partnership Workshop Summary (draft 2024)
- 2023 Update to the Mid-America Monarch Conservation Strategy (2023)
- USFWS Monarch Species Status Assessment (2020)

- Input from MJV network and interested parties via a listserv inquiry